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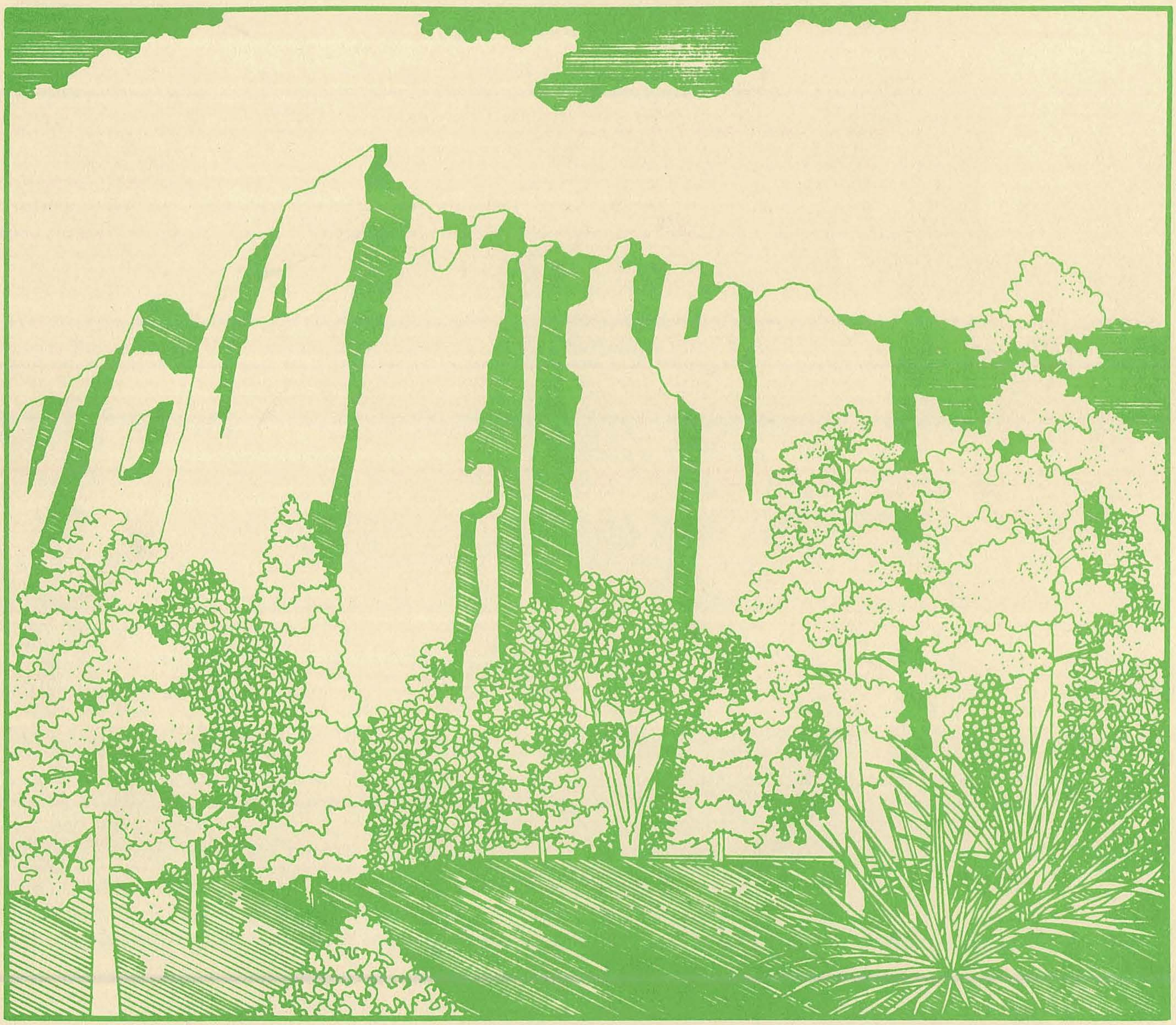
Forest Pest Management Report

R-3 85-11

WESTERN SPRUCE BUDWORM
SUPPRESSION PROJECT--1984

Lincoln National Forest, Mescalero Apache Indian
Reservation, and Adjacent Private Lands,
New Mexico

May 1985



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Much of the project planning, design, sampling, and timing of application was coordinated and conducted by William G. Telfer, forest entomologist, USDA Forest Service, Southwestern Region. Bill's conscientious, tireless efforts insured the success of this project. Regrettably, Bill was killed on July 23, 1984, while conducting aerial detection surveys over the Lincoln National Forest and Mescalero Apache Indian Reservation forested lands. The authors dedicate this project report to his memory.

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ABSTRACT

During May and June 1984, a western spruce budworm (WSBW) suppression project was conducted on 240,900 acres of mixed conifer forests in the Sacramento Mountain Range of south-central New Mexico. The objective of the project was to reduce WSBW populations to as low a level as possible, thereby protecting visual quality and timber resources without the necessity of annual re-treatments. Bacillus thuringiensis (B.t.) was aerially applied to sensitive areas where human habitation or water bodies were of concern, at the rate of 12 billion international units per acre. Carbaryl was aerially applied to remaining areas at the rate of 1 pound active ingredient per acre.

Organizational structure, application procedures, and evaluation of project effectiveness are discussed in detail. Postspray larval populations and egg mass densities indicate the project was successful in reducing the WSBW population throughout most of the treated area during 1984. Intensity of defoliation, as observed during 1984 aerial detection surveys, was lower than in 1983 and much lower than that predicted for 1984. With the per acre cost estimated at $5.87 and no reported personnel injuries, the project met the efficiency and safety objective.

INTRODUCTION

The current outbreak of western spruce budworm (WSBW), *Choristoneura occidentalis* Freeman, on the Lincoln National Forest (LNF), Mescalero Apache Indian Reservation (MAIR), and interspersed private lands was first detected in 1981 during aerial detection surveys when 625 acres of mixed conifer defoliation was recorded. Area of visible defoliation increased to 6,625 acres in 1982 and 108,800 acres in 1983 (Telfer 1983). As a result of this outbreak and the prediction of continued defoliation with resultant damages, the USDA Forest Service (FS) and cooperating agencies, including the USDI Bureau of Indian Affairs (BIA) and the New Mexico Departments of Agriculture (NMA) and Natural Resources (NMNR), conducted an environmental analysis to determine the most appropriate action against this outbreak. The analysis was documented in an environmental assessment. Decision Notices and a Finding of No Significant Impact were issued by LNF Supervisor, Jim Abbott, and BIA Area Director, Vincent Little.[1] The decision was to utilize an integrated pest management approach which implemented the prevention alternative on all commercial forest lands; the suppression alternative using carbaryl and Bacillus thuringiensis (B.t.) on the Alamo, Cloudcroft, Mescalero, and Sacramento analysis

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[1]USDA Forest Service. Environmental assessment of western spruce budworm on Lincoln National Forest, Mescalero Apache Indian Reservation, and associated State and private lands. 1983. 69 p.

units; and protection of high-value trees or stands on the Ruidoso and White Mountain analysis units. This report documents the objectives, methods, and results of the suppression alternative implemented in 1984.

OBJECTIVES

The overall project objective was to reduce WSBW populations to as low a level as possible so that damages to visual quality and timber resources could be maintained at acceptable levels without annual re-treatments. An additional objective was to conduct the suppression project in an efficient and safe manner.

PROJECT ORGANIZATION

This project was administered by personnel from the LNF with the assistance of personnel from the following agencies: MAIR, BIA, NMA and NMNR, and Forest Pest Management (Washington Office, Southeastern Area, Boise Field Office, Rocky Mountain Region, and Southwestern Region). Technical assistance was provided throughout the project by representatives from Abbott Laboratories and Union Carbide. Appendix A shows a project organizational chart.

TREATMENT AREA

This project was conducted over 240,900 acres of WSBW-infested mixed conifer forests (Douglas-fir and white fir species are the principal budworm hosts) in the Sacramento Mountain Range of south-central New Mexico (appendix B) and included portions of the LNF, MAIR, and interspersed private lands. Topography of the area varied from rugged canyons to gently sloping alluvial fans. Elevations ranged from 6,000 to 11,000 feet mean sea level.

Treatment area was divided into 25 blocks, ranging in size from 6,000 to 11,000 acres. Block establishment was based on the following factors: Similar topography, minimal elevational differences, adequate vehicular access, and manageable size (high probability of single-day treatment). Block locations are shown in appendix C.

TIMING OF APPLICATION

Proper timing of application was essential. Sequence of application depended upon the stage of budworm larval and host-tree bud development within each treatment block. Beginning in early May, treatment blocks were inspected daily for budworm and host-tree bud development. Once host-tree buds began to swell, larval development sampling was initiated and continued on an every-other-day basis. Larval developmental data were taken from 15 sample plots located throughout the elevational range of each treatment block. Larvae collected at these

plots were examined at the project laboratory to determine the average percentage of WSBW larvae in each larval instar for each treatment block. Carbaryl treatment blocks were released for spraying when 20 percent of the WSBW larvae reached the fifth instar and Douglas-fir bud flush had occurred. B.t. treatment blocks were released for spraying when 50 percent of the WSBW larvae reached the fourth instar and Douglas-fir bud flush had occurred. White-fir bud flush occurred several days earlier than Douglas-fir.

INSECTICIDES

Insecticides were B.t. and carbaryl. B.t. was aerially applied to sensitive areas where human habitation and major water bodies, such as streams and ponds, were of concern. Remaining areas were aerially treated with carbaryl. A summary of background information on these insecticides, including environmental hazards, can be found in Appendix A, Western Spruce Budworm Management Program, Santa Fe National Forest, Draft Environmental Impact Statement (1983).

B.t. (Dipel 6L)[2] was applied at 12 billion international units (BIU's) per acre. Formulation consisted of Dipel 6L (48 BIU/gallon) diluted 1:1 with water, then applied at the rate of 64 ounces per acre.

Carbaryl (Sevin 4 oil)[3] was applied at 1 pound active ingredient per acre. The Sevin 4 oil was diluted 1:1 with diesel and applied at the rate of 64 ounces per acre.

AIR OPERATIONS

Air operations were based at the Alamogordo Municipal Airport, Alamogordo, New Mexico. All treatment areas were within 35 air miles of this base.

Contracting. Insecticides, aerial application, and observation helicopter services were obtained through four separate solicitations.

The aerial application contractor furnished all labor, transporation, and equipment to aerially apply pesticide formulations to approximately 16,000 acres per day, including personnel and equipment to transfer, hold, mix, and load insecticide formulations.

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[2]Abbott Laboratories trade name for B.t.
[3]Union Carbide Corporation trade name for carbaryl insecticide; 4 pounds active ingredient per gallon.

The helicopter contractor furnished four standard factory-equipped helicopters, with pilots, and two service trucks, with drivers. The helicopters were turbine powered with a minimum of 420 shaft horsepower; capable of hovering in ground effect at 11,000 feet m.s.l. and 21° C, with a payload of 420 pounds using actual pilot weight and fuel for 1 hour and 30 minutes; and with a minimum seating capacity of 4 passengers.

Insecticides were procured through separate contracts. The respective contractors furnished and delivered an estimated 45,000 gallons of Sevin 4 oil and an estimated 12,500 gallons of B.t.

Aircraft Characterization. Knowledge of spray deposit characteristics was essential for an effective operation. For the insecticide Sevin 4 oil, data and experience acquired during previous projects were sufficient. For B.t., additional data were needed, since improved formulations and new application techniques were constantly being developed. To obtain this data, spray characterization trials were conducted in Litchfield Park, Arizona, during April 10-12, 1984.

The trial objective was to determine an optimum B.t. dilution rate spray nozzle configuration, and nozzle size for specific use during the Region's 1984 B.t. spraying programs. The trial design followed methods described by Dumbauld and Rafferty (1977), principally the collection and assessment of droplet density and volume median diameter (VMD) data. Dipel 6L (Abbott Laboratories) and Thuricide 32 LV (Zoecon Corporation)[4] were assessed at various dilution rates, nozzle configurations, and nozzle sizes. A Marsh Turbo-Thrush aircraft equipped with an airfoil boom and pressure nozzles was the trial aircraft.

The characterization trial results are presented in appendix D. For the insecticide Dipel 6L at 12 BIU per acre, trials were conducted for 32 ounces per acre (undiluted), 64 ounces per acre (1 part B.t. to 1 part water), and 96 ounces per acre (1 part B.t. to 2 parts water) application rates with various nozzle configurations. Data for the 96-ounce applications were not analyzed. Spray drift and lifting was so obvious at the trial, the 96-ounce dilution was dropped from consideration at this point.

Based on characterization trial results, Dipel 6L was applied at 64 ounces per acre with nozzles oriented 45° forward. This rate resulted in a VMD in the 215 to 270 micron range with good drop recovery. While the 32-ounce per acre undiluted applications had fair results, the pressure nozzle system cound not deliver the desired smaller VMD.

[4]The insecticide Thuricide 32 LV was applied during the 1984 Carson National Forest western spruce budworm suppression project.

The characterization trials were conducted with the assistance and cooperation of Forest Pest Management, Davis, California, Abbott Laboratories, and the Zoecon Corporation.

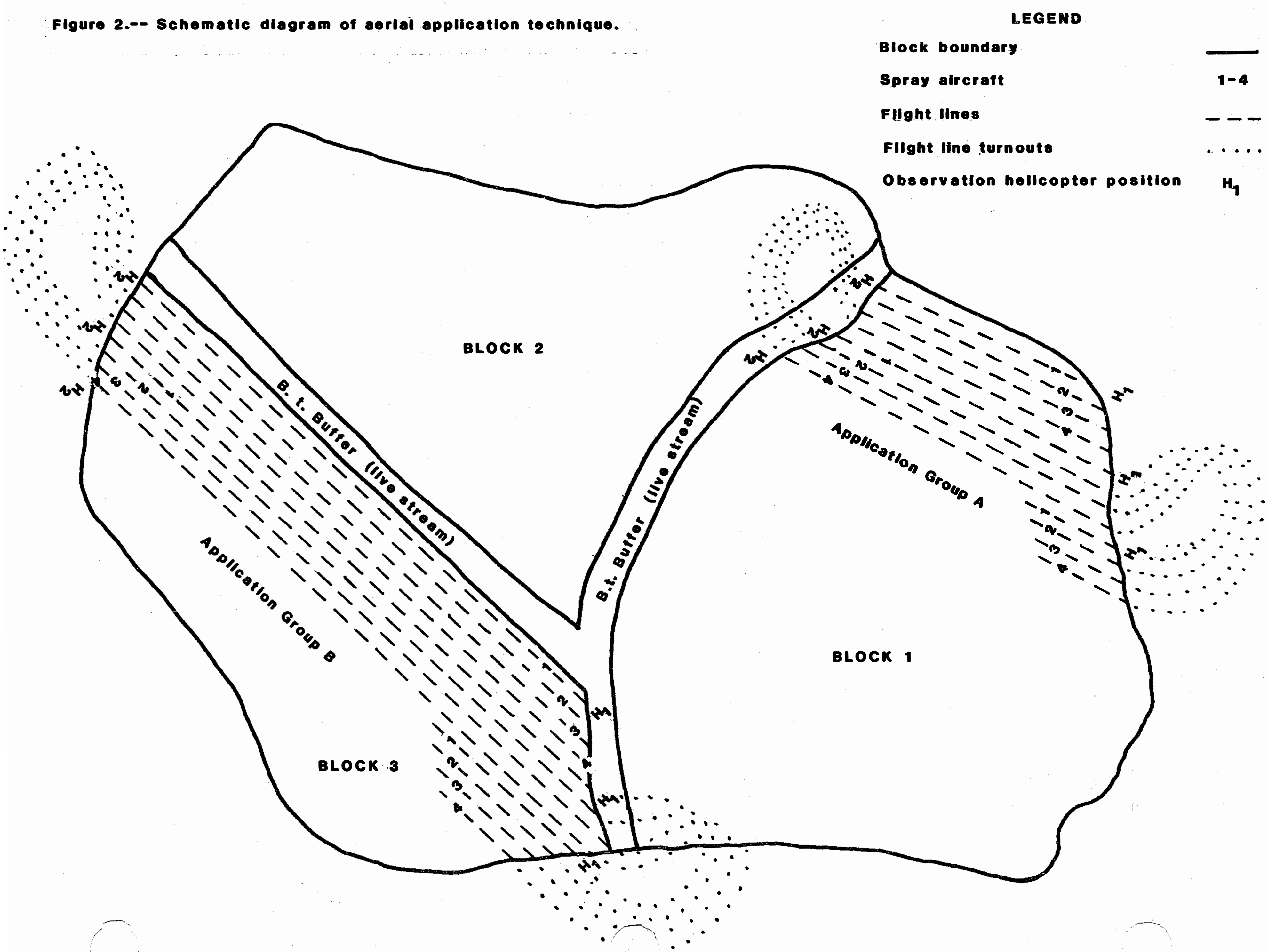
Application--Technique and Logistics. Using past experience and careful planning, Forest Pest Management personnel determined the most effective, efficient, and safe application method was using two separate air application groups (A&B), each capable of treating 8,000 acres per day. Each group consisted of four fixed-wing spray aircraft, piloted by experienced applicators, and two helicopters, with pilots and experienced aerial observers. The fixed-wing aircraft in group A were all identically equipped Air Tractor 400 models. Group B contained two Air Tractor 400 aircraft and two Ayers Turbo-Thrush aircraft. All fixed-wing aircraft were equipped with airfoil spray booms and wind-driven pumps. The spray delivery system utilized pressure nozzles with flat fan tips. Helicopters in each group were one Hughes 500D and one Bell 206 Jet Ranger.

Application groups operated independently. While both groups were often simultaneously treating their respective blocks, they were separated by at least one, and usually several miles to guard against overcrowded airspace. While in flight, the four fixed-wing aircraft of each group operated in a single formation (figure 1). During

FIGURE 1--Four turbine-powered aircraft operating in a single formation

application, the two observation helicopters were positioned as "flags" at opposite ends of the spray swath to aid spray aircraft in orientation (figure 2). Through radio communication, aerial observers onboard the helicopters directed the spray aircraft's heading, maintained proper swath width, and assured aircraft released the

Figure 2.-- Schematic diagram of aerial application technique.



insecticide within the appropriate treatment boundaries. Aerial photography (U.S. Geological Survey Orthophotoquads), marked with block boundaries and reference points, was used by the aerial observers to aid in orientation and to record direction and location of each spray swath.

Appendix E schematizes application logistics during a "typical" spray day. Spray operations began each morning at 5 a.m. with a brief operations meeting between the project director, spray operations manager, project air officer, air service managers, aerial observers, and pilots. Discussed at these meetings were spray block locations, primary and secondary swath direction, air hazards near or within spray blocks, weather conditions and forecasts, and safety precautions.

Observation helicopters generally departed Alamogordo Municipal Airport between 5:20 and 5:30 a.m. Helicopter groups flew to their respective spray block, hovered at treetop level to determine windspeed and direction, then if conditions allowed treatment, the lead observer radioed the project spray operations officer to dispatch spray aircraft. Spray aircraft ferried to the spray block, applied their load, returned to Alamogordo, and reloaded in an average turnaround time of 60 to 70 minutes. Following application of each load, observation helicopters landed and refueled at a designated helispot, located near the treatment area. This reduced helicopter flight time, and allowed observers to compare swath locations and discuss problems or plans for subsequent loads. Observers were notified by radio when their spray aircraft were departing Alamogordo, thus enabling them time to position for the next load. Application continued until excessive wind and or thermal convections precluded safe, effective treatment, at which time the lead observer, for his respective group, discontinued application. Spray aircraft and helicopters then returned to Alamogordo where a spray operations meeting was convened to discuss the day's application (problems, recommended changes in procedure, safety precautions, the following day's spray block location, etc.). Following this meeting, a reconnaisance flight for aerial observers and lead spray aircraft pilots was conducted to become familiar with the following day's block location, terrain potential safety hazards, and to establish primary and secondary swath directions. All daily spray operations tasks were generally concluded by 12 m.

Aircraft Calibration. All eight spray aircraft were calibrated to deliver 64 ounces per acre of Sevin 4 oil immediately prior to the spray program's start. Prior to commencing the *B.t.* treatment, four spray aircraft were recalibrated to deliver 64 ounces per acre Dipel 6L. All aircraft were calibrated at 140 miles per hour ground speed and 150-foot swath width.

Insecticide Mixing and Loading. All insecticide mixing was completed at the Alamogordo Municipal Airport. Contractor furnished-equipment included three insecticide storage tanks with a total capacity of

approximately 21,000 gallons, 4 each 1,500-gallon mixing tanks, aircraft fuel storage tanks, flowmeters, pumps, and hoses. The contractor furnished all labor necessary to mix insecticides and load the spray aircraft. Insecticides were delivered in bulk and offloaded into the contractor's storage tanks. The Forest Service provided the diesel oil diluent for the Sevin 4 oil and the water diluent for the Dipel 6L. The diesel oil was stored in two leased tanks with a total capacity of 40,000 gallons. Water was piped from the nearby Lincoln National Forest Air Tanker Base on demand.

Spray aircraft were loaded by flight, using two mix/load tanks per flight. Initially, all aircraft applied Sevin 4 oil. Beginning May 30, one flight (four aircraft) was converted and recalibrated to apply Dipel 6L. Air Tractor 400 aircraft were loaded with 325 to 375 gallons of insecticide, depending on terrain being sprayed. The Ayres Turbo-Thrush aircraft were loaded with 300 to 325 gallons of insecticide.

Meteorology. Early morning weather data collected on spray blocks were transmitted to the National Weather Service (NWS) in Albuquerque, New Mexico. Using this information, meteorologists from the NWS made next day forecasts which included probability of precipitation during the subsequent 24-, 48-, and 72-hour period, wind direction and speed, relative humidity, and temperature gradients in the spray area. These remarkably accurate forecasts were essential in determining if local weather conditions favored or precluded application. Spray operations commenced if the probability of precipition was less than 30 percent during the next 24 to 48 hours and windspeed at treatment blocks was less than 10 miles per hour. If either of these conditions was not met, spray operations were delayed or canceled.

Communications. An efficient, effective communications system was vital to the success of the project. A communications officer was assigned to the project and given the responsibility for all aspects of radio communication, including development, implementation, and monitoring effectiveness of a communication plan. Air-to-air, air-to-ground, and air-to-base communications were maintained through the aerial observers. Spray aircraft were equipped with a fully operational 360 channel VHF communication transceiver enabling spray pilots to communicate with each other, with aerial observers, and with the airport traffic controller. Helicopters were equipped with a 720 channel communications transmitter/receiver system, including headset jacks and "push-to-talk" switches for a minimum of pilot and three observers. This allowed aerial observers to communicate with spray pilots, other aerial observers, and the base operations at Alamogordo Municipal Airport. Helicopters were also equipped with one Government-furnished auxiliary FM portable radio to allow direct communication with field crews. In addition, the two helicopters carrying lead observers were equipped with a Government-furnished 9600 channel VHF-FM transceiver. This allowed direct communication on LNF and MAIR frequencies.

Air-to-ground communications were monitored by a dispatcher at the base of operations using a 720 channel radio and a multichannel FM portable radio containing Forest frequencies. FPM radio cache packset radios were provided for field personnel to communicate with base operations dispatchers, with other field crews, and with aerial observers.

Thus equipped, effective radio communications were maintained between all spray operations personnel through a predetermined set of frequencies. A communications profile is shown in appendix F.

SAFETY

Safety was stressed throughout the project. The project safety officer developed safety plans; enforced safe working practices; acted as an accident investigation officer; monitored the execution of safety plans; and advised project director on safety-related problems. A project safety plan, a safety action plan, and a pesticide safety plan were included within project work plan and provided to project personnel. Five security officers were assigned to the project to protect Federal property and personnel at the Alamogordo Municipal Airport on a 24-hour basis.

Accidents and Incidents. No injuries or time lost due to injuries or accidents occurred during this project.

Insecticide Spills. Two pesticide spills occurred. On May 25, 10 to 15 gallons of carbaryl were spilled at the mixing/loading site while offloading a tanker trailer. Excess pressure in a hose line caused a cam lock fitting to open and spill insecticide. The spill was contained, cleaned up, and the contaminated soil properly disposed of at the Alamogordo Sanitary Landfill.

The second spill occurred on the morning of June 6 when a spray aircraft enroute to the spray area jettisoned 20 to 30 gallons of diluented carbaryl in order to climb over a ridge. This "dump" occurred over an isolated, nonforested, rocky ridge west of Alamo Peak. Because of inaccessability, absence of livestreams, and diluted nature of the spill, no attempt was made to contain or clean up the affected area.

PROJECT COST

Total project cost was $1,413,536, or $5.87 per acre. A breakdown of expenses follows:

Item	Item cost	Total cost
Insecticides		
Carbaryl	$674,100	
B.t.	205,000	
Diesel[5]	6,580	$ 885,680
Application		
Spray aircraft	190,363	
Helicopters	84,363	
		274,726
Equipment rental		12,600
Supplies		11,032
Overhead: salaries, overtime, and travel		
Lincoln NF	168,400	
Forest Pest Management	38,088	
		206,488
Environmental monitoring		14,350
Characterization trials		8,660
Total project cost		$1,413,536

EVALUATION OF PROJECT EFFECTIVENESS

Project effectiveness was evaluated primarily by postspray larval population levels. Subsequent egg mass density and defoliation estimates were also used to evaluate project effectiveness. A spray deposit assessment was conducted to determine if target areas were treated, and an environmental monitoring effort measured the impacts on aquatic organisms resultant from accidental overspraying or drift of carbaryl into streams.

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[5]Approximately 38,000 gallons of diesel was obtained for transportation from the Los Alamos National Laboratories as surplus.

Larval Population Reduction. Success of the project was primarily gaged upon whether or not postspray larval populations were at or below 5 per 100 buds. Data from a previous suppression project conducted against WSBW in the southwest have shown that residual larval populations at or below these levels can result in acceptable foliage protection for several years (Telfer 1982). Prespray and postspray mean larval densities, presented in table 1, show the project was successful in reducing the larval population to this acceptable level on 21 of the 25 treatment blocks. The remaining 4 blocks (Cloudcroft, La Luz, Pumphouse, and Wayland) had mean postspray larval populations ranging from 5.24 to 8.54; however, these residual populations were still markedly reduced from prespray levels.

Efficacy of treatment, in terms of population reduction, may have been lessened on some blocks by a combination of adverse climatic factors and variability in application. Precipitation data presented in appendix G show localized precipitation occurred within or near the project area on May 25 and 31 and June 2 and 3. Blocks treated on these dates with oil-soluble carbaryl, which became rain fast once dried (Union Carbide Corporation 1978), included Walker, Firman, Goat Lake, Lucas, Nogal, and Turkey Pen, each of which achieved acceptable reductions in larval population. However, localized precipitation on May 31 (.50 inches) may have reduced the effectiveness of the water-soluble B.t. application on the La Luz block, where the postspray larval density was 8.54±.88 per 100 buds. Heavy precipitation following the June 2 B.t. application on the Cloudcroft block (.27 inches on June 2 and .49 inches on June 3) also could have reduced the effectiveness of treatment. However, to insure effectiveness, 5,550 acres of this high-use recreational block (Cloudcroft) were re-treated with B.t. on June 5-6.

Other climatic factors which may have reduced efficacy of treatment include periodic wind gusts and thermal lifting during application. Winds gusts, probably in excess of 10 miles per hour, were noted by aerial observers during application of the Wayland block (May 27) and re-treatment of Cloudcroft block (June 5). Thermal lifting was noted during the third load of the Dark Canyon block application (May 26).

Variability in application may also account for some reduction in the efficacy of treatment. Excessive and abrupt elevational changes in the Dark Canyon, Scott Able, and Wills blocks varied larval and bud development, thus confounding proper timing of the application. In addition, uniformity of application may have been impeded because spray aircraft could not always maintain constant forward airspeeds and heights above the canopy over some of the more rugged terrain.

Egg Mass Densities. Egg mass density surveys conducted throughout LNF and MAIR analysis units in 1983 and within treatment blocks in 1984 also indicated a WSBW population reduction following treatment. Results of these surveys, presented in table 2, show a large decrease in egg mass densities throughout the treatment area from 1983 to 1984.

TABLE 1.--Mean larvae per 100 buds for prespray and 14-day postspray samples, Lincoln National Forest and Mescalero Apache Indian Reservation suppression project, 1984

Block designation	Insecticide used	Larvae per 100 buds	
		Prespray	14-day postspray
Apache Summit	Carbaryl	10.96 S.E.=2.21	.96 S.E.=0.28
Baird	Carbaryl	16.84 S.E.=2.78	3.50 S.E.= .56
Cloudcroft	*B.t.*	20.25 S.E.=2.17	5.24 S.E.= .59
Cooley	Carbaryl	10.64 S.E.=2.72	1.91 S.E.= .30
Dark Canyon	Carbaryl	13.89 S.E.=1.58	4.72 S.E.= .78
Firman	Carbaryl	13.88 S.E.=1.69	3.05 S.E.= .63
Five Canyon	Carbaryl	23.93 S.E.=7.35	2.58 S.E.= .96
Goat Lake	Carbaryl	13.18 S.E.=3.68	1.69 S.E.= .35
James Canyon	*B.t.*	12.90 S.E.=1.52	3.74 S.E.=1.27
La Luz	*B.t.*	19.26 S.E.=1.83	8.54 S.E.= .88
Lucas	Carbaryl	17.31 S.E.=2.60	1.80 S.E.= .50
Moore Canyon	Carbaryl	16.98 S.E.=2.16	1.46 S.E.= .38
Nogal	Carbaryl	10.14 S.E.=1.12	.77 S.E.= .24
Penasco	Carbaryl	21.34 S.E.=3.07	2.31 S.E.= .96
Penasco	*B.t.*	15.88 S.E.=3.70	1.62 S.E.= .27
Pumphouse	Carbaryl	20.31 S.E.=2.23	7.30 S.E.=1.82
Sawmill	Carbaryl	16.93 S.E.=3.66	.84 S.E.= .22
Scott Able	Carbaryl	24.43 S.E.=5.15	4.14 S.E.= .95
Spring Canyon	Carbaryl	10.86 S.E.=1.83	1.13 S.E.= .24
Turkey Pen	Carbaryl	17.35 S.E.=3.59	1.77 S.E.= .37
Walker	Carbaryl	13.22 S.E.=1.54	2.65 S.E.= .75
Water	Carbaryl	14.99 S.E.=2.87	1.36 S.E.= .43
Wayland	Carbaryl	22.54 S.E.=2.20	7.16 S.E.=1.11
Wills	Carbaryl	12.91 S.E.=1.42	3.63 S.E.= .62
Ruidoso	*B.t.*	9.60 S.E.=4.00	1.79 S.E.=1.11

TABLE 2.--Summary and comparison of 1983 and 1984 egg mass densities by analysis unit, Lincoln National Forest and Mescalero Apache Indian Reservation

Analysis unit	New egg masses per square meter of foliage ± S.E. and number of plots	
	1983	1984
Mescalero--Includes the following 1984 treatment blocks: Apache Summit, Baird (part), Cooley, Firman, Five Canyon, Goat Lake, James, Canyon (part), La Luz (part), Nogal, Turkey Pen (part), and Ruidoso	37.6±10.7 n=16	1.1±.53 n=73
Cloudcroft--Includes the following 1984 treatment blocks: Cloudcroft and La Luz (part).	49.2±7.2 n=10	.7±.7 n=3
Alamo--Includes the following 1984 treatment blocks: Baird (part), Dark Canyon, Lucas, Penasco, Pumphouse, Sawmill, Turkey Pen (part), and Walker	59.0±12.3 n=10	.5±.16 n=76
Sacramento--Includes the following 1984 treatment blocks: Moore Canyon, Scott Able, Spring Canyon, Water, Wayland, and Wills.	46.0±8.7 n=6	.9±.37 n=48

Defoliation. Figures 3 and 4 show areas of WSBW-caused defoliation as determined during 1983 and 1984 aerial detection surveys. Total acres defoliated increased from 84,000 in 1983 to 92,000 in 1984. However, the intensity of defoliation was less in 1984 than in 1983, and much less than the heavy defoliation predicted for 1984 (Telfer 1983). Because treatment was aimed at late instar larvae and postspray larval densities were greatly reduced, we conclude much of the observed defoliation in 1984 occurred prior to treatment.

Spray Deposit Assessment. An assessment of spray deposition was conducted to determine if sampling points were treated. No attempt was made to quantify the amount of spray deposit nor to correlate spray deposition with larval population reduction. Spray deposition was assessed by placing Sudan black cards in small clearings near larval sampling points prior to spraying. After spraying, cards were collected and the mean number of spray droplets per square centimeter per card was determined. Spray deposition was assessed on most, but not all, carbaryl treatment blocks. Logistical problems and last minute changes in treatment schedules precluded spray deposit assessment on Turkey Pen, Walker, and Water treatment blocks. *B.t.* was not discernible on deposit cards placed within the *B.t.* treatment blocks; therefore, deposition was not assessed in those areas.

Environmental Monitoring. Environmental monitoring was conducted both through air and ground surveillance. Aerial observers, who were orienting and directing the spray aircraft, monitored, recorded, and reported any overspray of sensitive areas or apparent spray drift out of the treatment block. Areas of overspray and drift included the following:

Area	Spray block	Date	Amount
Wills Canyon (Rio Penasco drainage)	Wills	5/24	2 swaths--4 aircraft
Cox Canyon (Rio Penasco drainage)	Pumphouse/Dark Canyon	5/26	1 swath--4 aircraft
Agua Chiquita (Sacramento River drainage)	Wayland	5/27	Drift
Sunspot	Moore	6/5	Drift

The areas of accidental overspray resulted from miscommunication between aerial observers or between aerial observers and spray aircraft pilots. The few incidents of drift resulted from abrupt changes in airflow speed and/or direction.

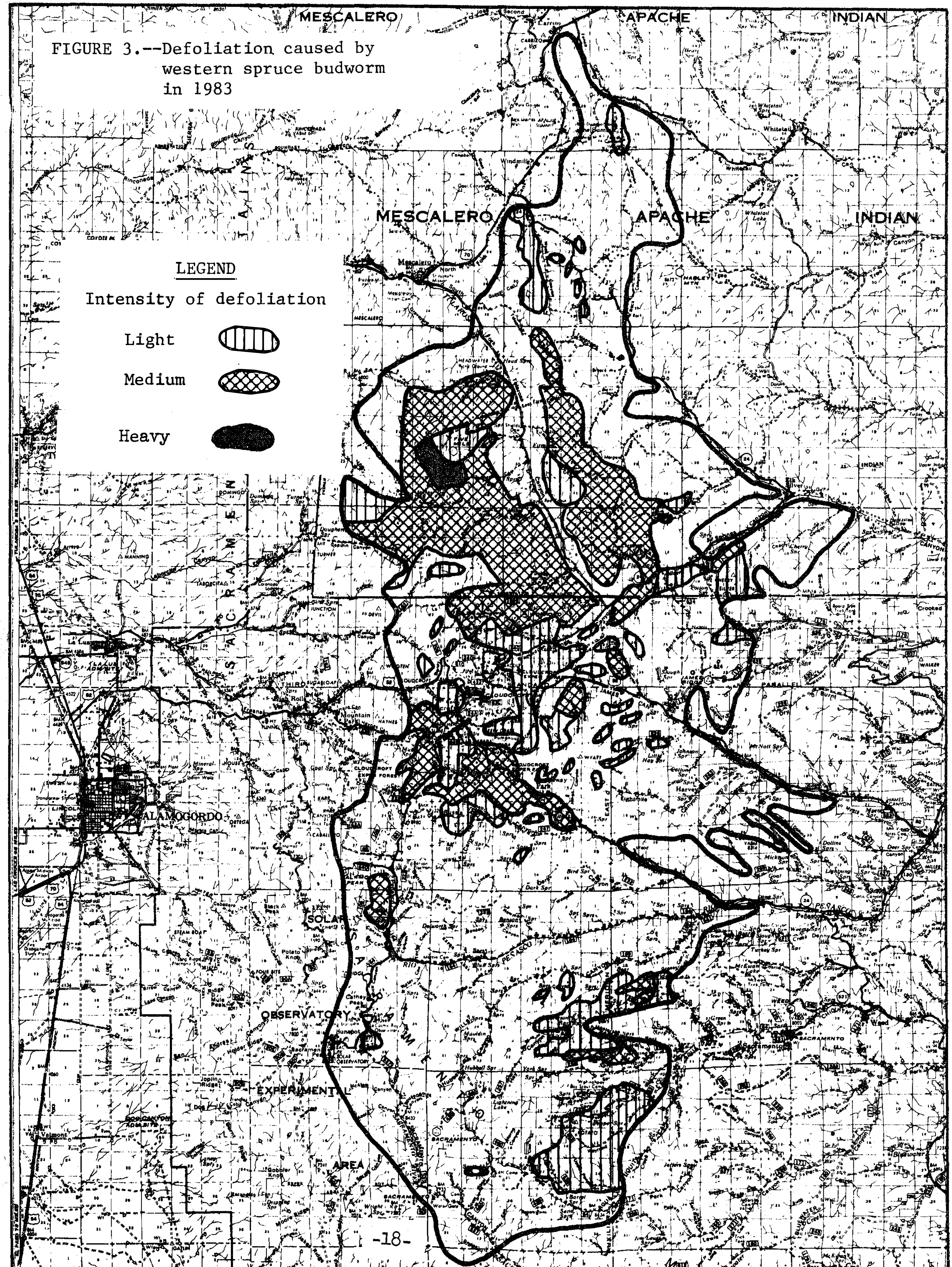
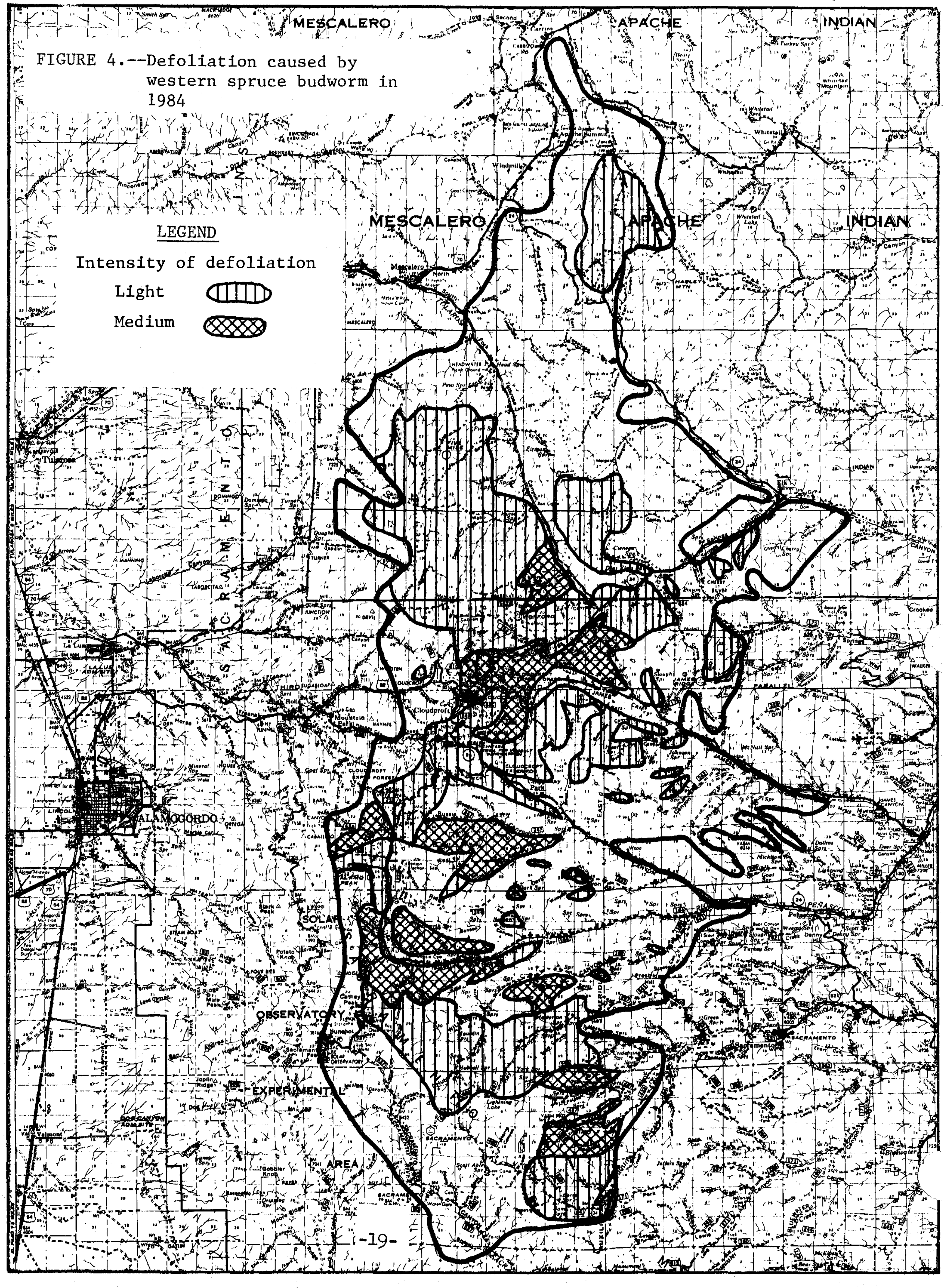


FIGURE 3.--Defoliation caused by western spruce budworm in 1983

FIGURE 4.--Defoliation caused by western spruce budworm in 1984



Impacts on aquatic organisms within the Sacramento and Penasco Rivers were monitored by personnel from the U.S. Fish and Wildlife Service. Macroinvertebrate samples were taken before and after carbaryl application to areas adjacent to these drainages. Generally, results of the aquatic monitoring show a significant reduction in macroinvertebrates within both rivers immediately following application to treatment blocks. These reductions resulted from accidental overspray (May 24 and 26) and drift (May 27 and June 5). A final report of the aquatic monitoring is presented in appendix H.

These reductions in aquatic macroinvertebrates are expected to be only temporary. Monitoring conducted on similar suppression programs in northern New Mexico indicated aquatic macroinvertebrate density and species diversity rebounded relatively quickly, within approximately 1 year (Kennedy 1977 and Kennedy and Sanchez 1982). In cooperative safety tests conducted on the Wallowa-Whitman National Forests in eastern Oregon (1975-77) as part of the Douglas-fir Tussock Research and Development Program, streams treated with carbaryl (2 lb/acre) also showed a marked reduction in aquatic insect populations immediately following application. However, most aquatic organisms, particularly mayflies, rebounded by the following year, when no significant difference in either population densities or species diversity was observed between treated and untreated streams (Pat Shea,[6] personal communication). Even severe, direct carbaryl spills into aquatic environments appear to have only temporary effects. During the 1983 western spruce budworm suppression program in Oregon (USDA Forest Service, Region 6), an accidental spill resulted in 1,900 gallons of carbaryl/diesel oil formulation (3,800 lb of carbaryl) entering Willow Creek. Initially, this spill was expected to have a catastrophic impact on the aquatic fauna; however, monitoring sponsored by the Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and the USDA Forest Service indicated aquatic macroinvertebrate populations recovered extremely quickly (Paul Buffam,[7] personal communication based on interim subject report).

CONCLUSIONS

Initially, the project objective of reducing WSBW populations was accomplished. In each treatment block, postspray larval densities were reduced from prespray larval densities. Defoliation was less intense in 1984 than 1983 and much less intense than predicted for 1984. Egg mass densities were sufficiently low in most areas to indicate defoliation intensities in 1985 will vary from undetectable to light. Budworm population monitoring in subsequent years is needed to fully assess project results.

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[6]Research entomologist, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.
[7]Director, Forest Pest Management, Region 6, USDA Forest Service.

With the per acre cost estimated at $5.87 and no reported personnel injuries, the project met the efficiency and safety objective.

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Union Carbide Corporation. 1978. Sevin 4 oil application and handling booklet. 11 p.

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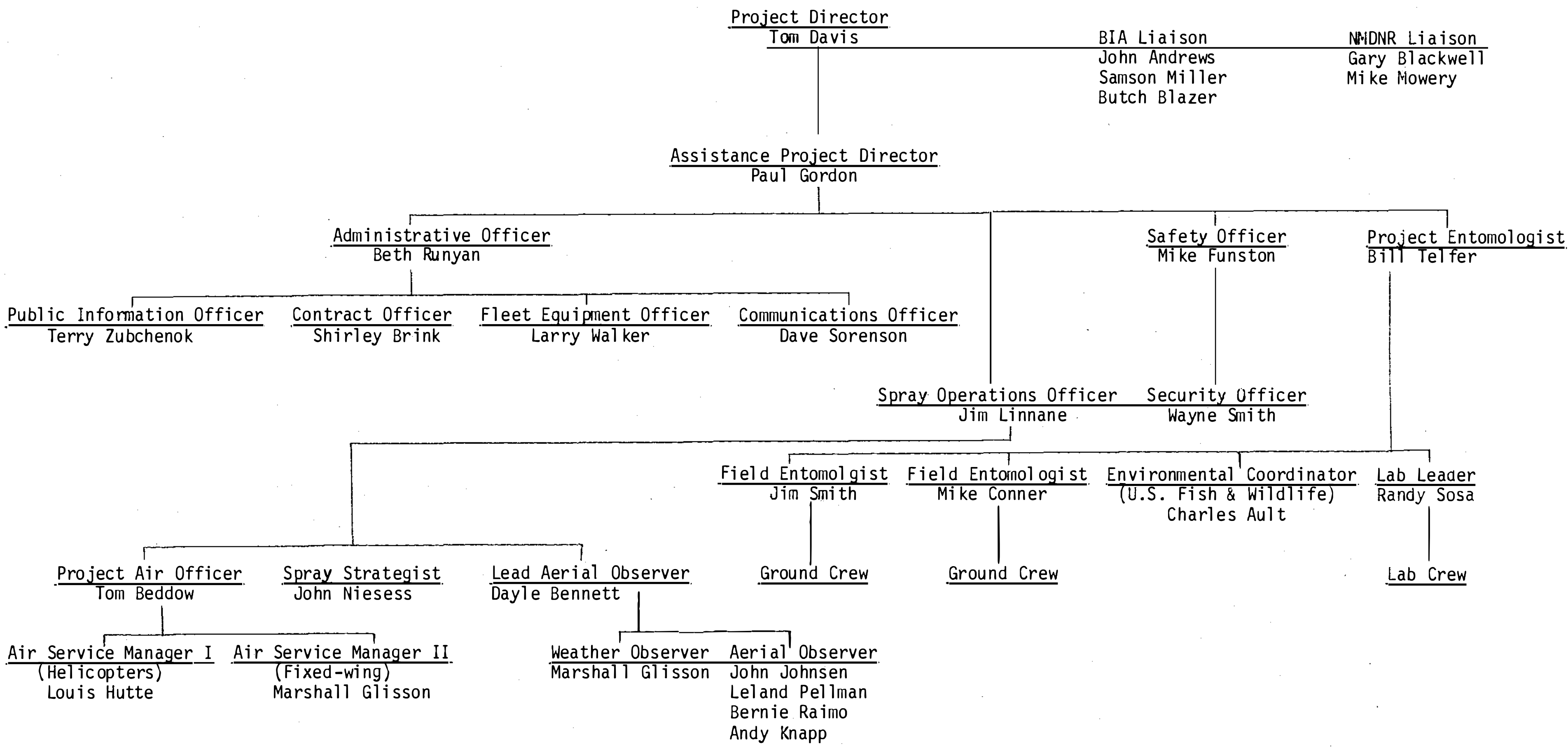
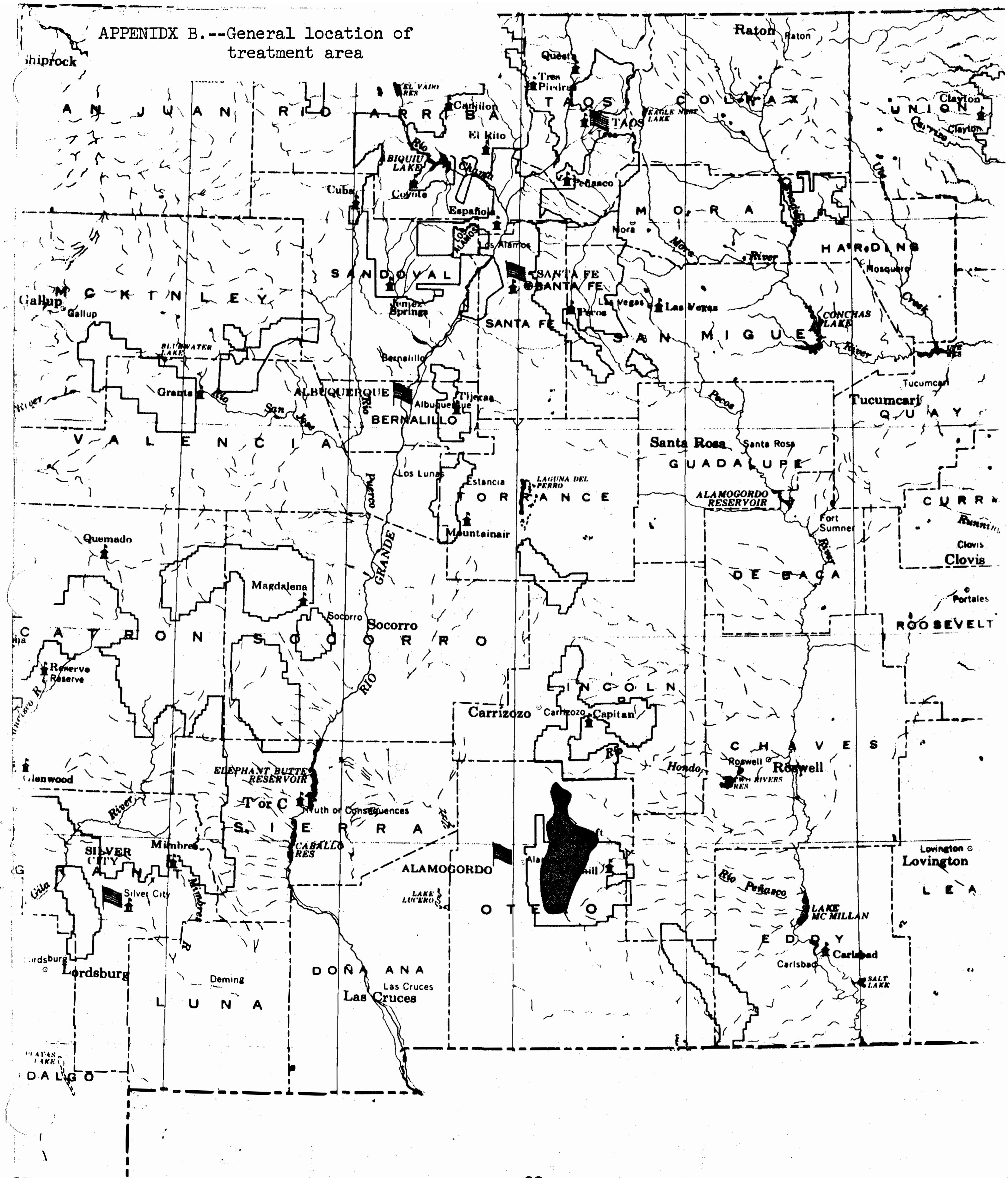
Parker, D. L. 1985. Western spruce budworm--Lincoln NF. USDA Forest Serv. letter biological evaluation. 6 p.

Union Carbide Corporation. 1978. Sevin 4 oil application and handling booklet. 11 p.

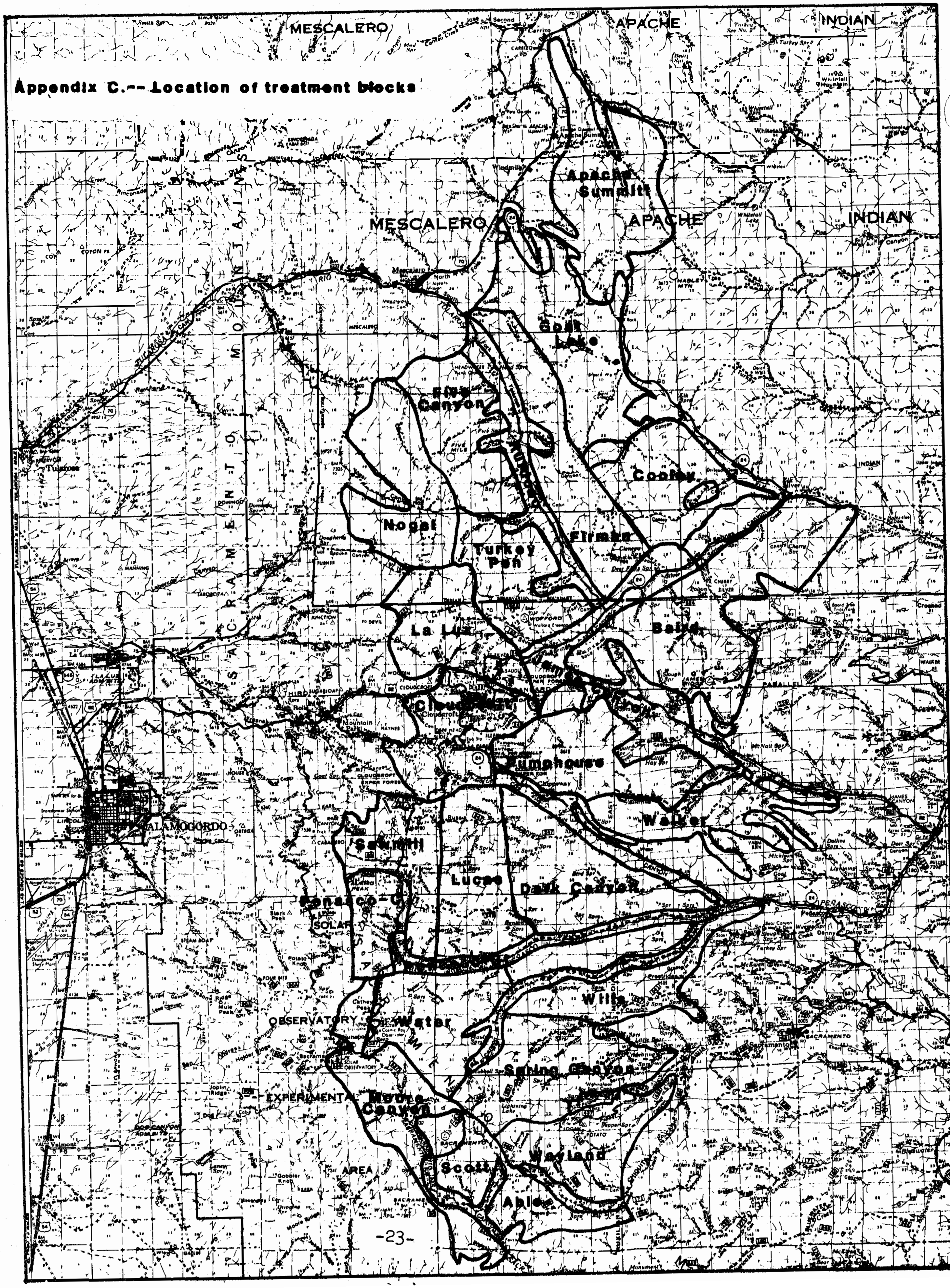
APPENDIX A.--Project organizational chart



APPENIDX B.--General location of treatment area



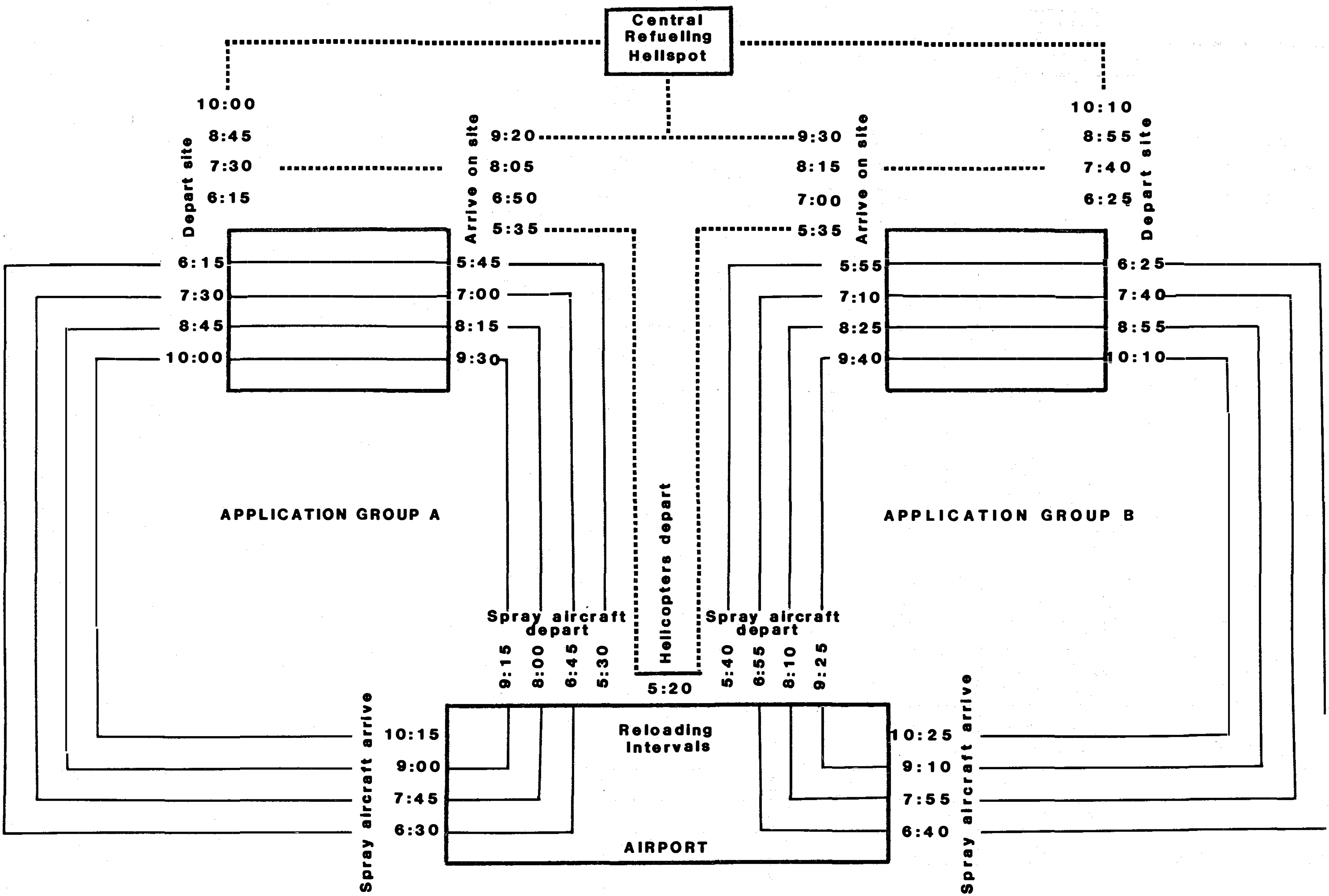
Appendix C.-- Location of treatment blocks



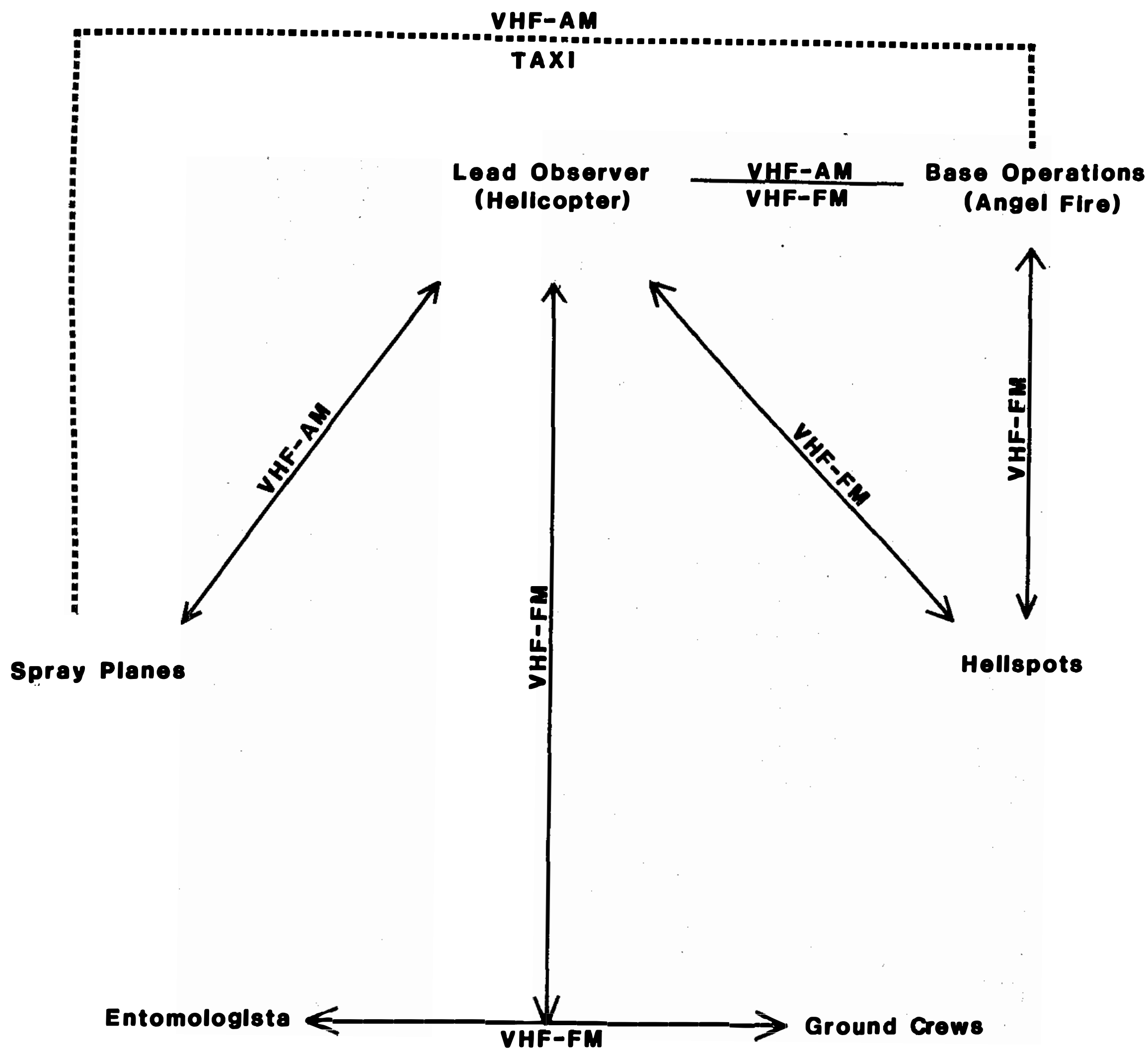
APPENDIX D.--Results of spray characterization trials conducted in Litchfield Park, Arizona, April 10-12, 1984

Trial number	Tank mix	Aircraft Speed (MPH)	Aircraft Release height (ft)	Meteorology Temp (°F)	Meteorology RH (%)	Meteorology W/S mph	Deposit data VMD (μM)	Deposit data Drops/cm²	Deposit data oz/ac	Deposit data Swath width (ft)	Nozzle Type	Nozzle Orientation
1	Dipel 6L Neat 32 oz/ac	150	50	52	52	5	337	25	N.D.[2]	150	8010	Straight down
	Dipel 6L Neat 32 oz/ac	150	50	52	52	5	314	25	N.D.	150	8010	Straight down
	Dipel 6L Neat 32 oz/ac	150	50	57	44	5	244	43	N.D.	260	8010	45° forward
	Dipel 6L Neat 32 oz/ac	150	50	65	36	5	339	22	N.D.	140	8006	45° forward
	Dipel 6L Neat 32 oz/ac	150	50	68	35	6	293	31	N.D.	160	8006	45° forward
	Dipel 6L 1:1 64 oz/ac	150	50	69	36	0	257	39	25	210	8006	45° forward
	Dipel 6L 1:1 64 oz/ac	150	50	69	33	2	214	23	16	160	8006	45° forward
	Dipel 6L 1:1 64 oz/ac	150	50	50	68	4	271	38	25	260	8006	45° forward
	Dipel 6L 1:1 64 oz/ac	150	50	52	42	5	215	12	8.1	140	8006	45° forward
	Thuricide 32 LV Neat 48 oz/ac	150	50	58	47	5	N.D.	16	N.D.	230	8008	Straight down
	Thuricide 32 LV Neat 48 oz/ac	150	50	60	49	4	N.D.	12	N.D.	300	8008	Straight down
	Thuricide 32 LV Neat 48 oz/ac	150	50	64	35	5	N.D.	24	N.D.	210	8008	Straight down
	Thuricide 32 LV 3:1 64 oz/ac	150	50	68	24	2	113	18	10	250	8008	Straight down
	Thuricide 32 LV 3:1 64 oz/ac	150	50	70	25	2	98	16	7	280	8008	Straight down
	Thuricide 32 LV 3:1 64 oz/ac	150	40	56	N.D.	3	146	27	19	230	8008	Straight down
	Thuricide 32 LV 3:1 64 oz/ac	150	40	55	44	5	115	18	12	250	8008	Straight down
	Thuricide 32 LV 3:1 64 oz/ac	150	40	56	45	4	96	26	11	250	8008	45° forward
	Thuricide 32 LV 1:1 96 oz/ac	150	50	68	32	3	95	22	11	250	8010	Straight down
	Thuricide 32 LV 1:1 96 oz/ac	150	50	70	34	2	93	10	5	330	8010	Straight down

[1]Aircraft was a Marsh Turbo-Thrush, boom pressure 40 p.s.i.
[2]No data available due to spread factor inconsistencies.



APPENDIX E.--Diagram of "typical" spray day application logistics



APPENDIX F.--Project communications profile

APPENDIX G.--Summary of project precipitation

Reporting station	May												June							
	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8
Cloudcroft	0	0	0	0	.10	1.00	0	0	0	T	0	0	0	.27	.49	0	0	0	0	0
Mayhill	0	0	0	0	0	0	0	0	0	0	0	.50	0	.20	.98	0	0	0	0	0
Mescalero	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.15	0	0	0	0	0

APPENDIX H.--Aquatic monitoring report

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Field Supervisor
Ecological Services, USFWS
Post Office Box 4487
Albuquerque, New Mexico 87196

April 17, 1985

Mr. Milo J. Hassel, Regional Forester
U.S. Forest Service
517 Gold Avenue SW
Albuquerque, New Mexico 87102

Dear Mr. Hassel:

During May 1984 the U.S. Forest Service (FS) conducted aerial spraying of the insecticide Sevin-4-oil (Carbaryl) in conjunction with its spruce budworm (Choristoneura occidentalis) suppression project on the Lincoln National Forest in Otero County, New Mexico. The U.S. Fish and Wildlife Service (Service) conducted monitoring surveys on the Rio Penasco and Sacramento River to detect carbaryl related mortality and recovery of aquatic macroinvertebrates resultant from accidental overspray or drift of carbaryl into either stream.

The streams included in the survey are located in the Lincoln National Forest in southcentral New Mexico (Figure 1). Bailey (1978) classifies the area as being in his Colorado Plateau Province, Grama-Calleta Steppe/ Juniper-Pinyon Woodland Section. Hammond (1964) describes the land surface form as Intermontane, Basin and Range Area with low mountains. The Rio Penasco and Sacramento River are perennial drainages that support introduced salmonid fisheries.

This report is based upon the final analysis of May pretreatment and June posttreatment benthic samples collected from the Rio Penasco and Sacramento River. Partial analysis of the Rio Penasco's July and October benthic samples and pretreatment, acute and posttreatment drift samples are also included. No analysis of drift samples and July-October post-treatment benthic samples from the Sacramento river are included here due to their being incomplete at this writing. Preparation of a report including all final anaylysis is planned to be prepared during the last quarter of FY-85.

METHODS

Aquatic macroinvertebrate sampling was conducted on the Rio Penasco and Sacramento River relative to the occurrence of carbaryl spraying within either drainage area. Carbaryl spraying, on the Lincoln National Forest,

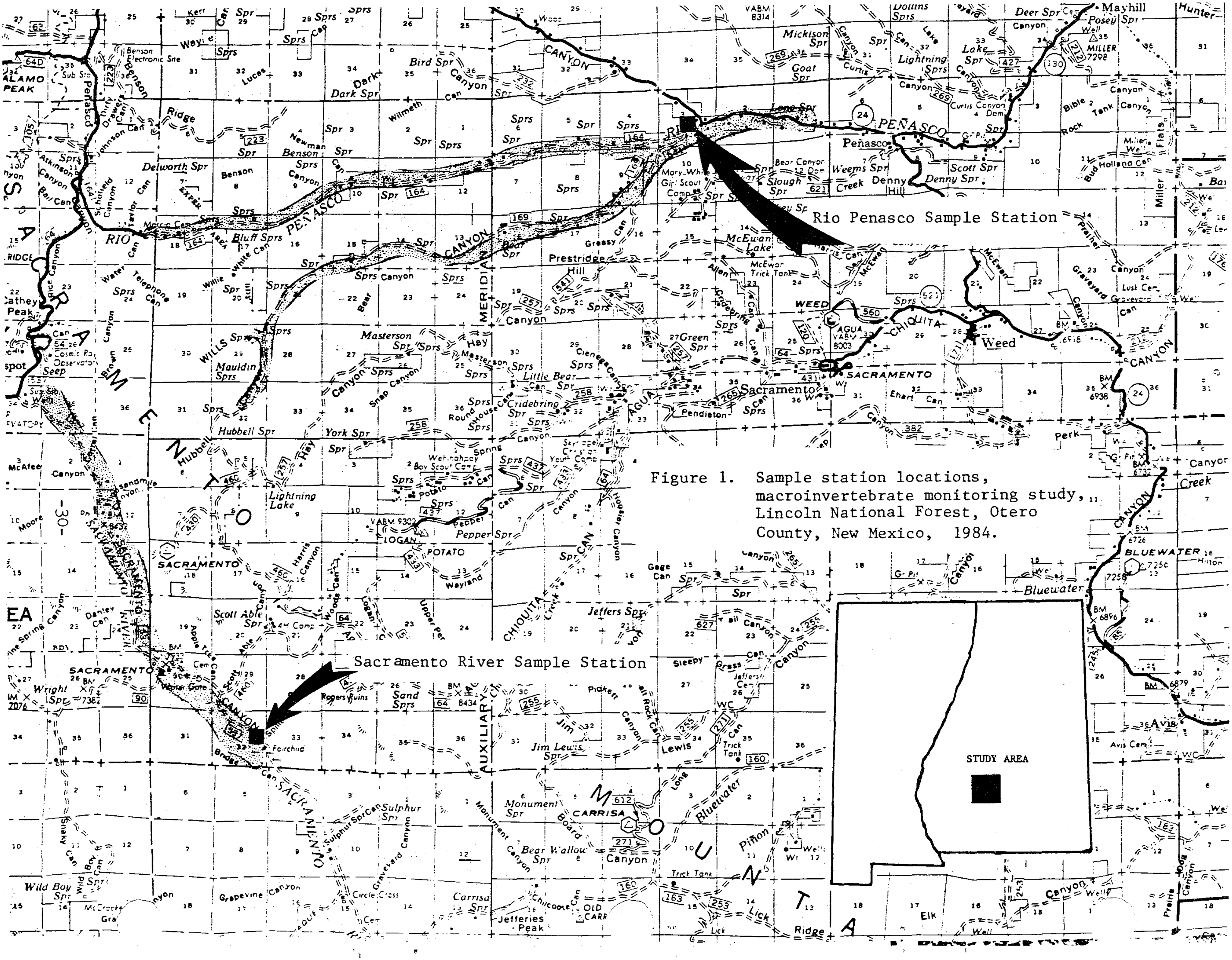


Figure 1. Sample station locations, macroinvertebrate monitoring study, Lincoln National Forest, Otero County, New Mexico, 1984.

began, intermittently occurring, on the morning of May 22 and ended on June 4, 1984. One sample station was established on each stream at the downstream terminus of the treatment area.

Benthic Sampling

Benthic sampling was conducted prior to carbaryl spraying (pretreatment) and after spraying (posttreatment) in order to describe changes, if any, in benthic macroinvertibrate densities and species composition in either stream relative to the effects of carbaryl contamination. Pretreatment bentic samples were collected from both streams on May 1 and 2, 1984, 21 and 20 days prior to initiation of carbaryl spraying. Posttreatment, benthic samples were collected on June 20, July 17 and October 22, 1984 or 20, 44 and 142 days respectively after spraying. All benthic sampling and analyses were conducted according to Winget and Mangum (1979) and the U.S. Forest Service (1983).

Drift Sampling

Drift sampling was conducted before, during (acute) and after spraying to detect changes in drift patterns, if any, of macroinvertibrates in both streams, and in one tributary (Wills Canyon), to the Rio Penasco relative to the effects of carbaryl contamination. The sampling scheme was designed to describe diurnal, crepuscular and nocturnal drift patterns of macroinvertebrates. A square drift net ($0.1m^2$ frame) was set in the stream for 15 minutes at approximately sunset, midnight, sunrise and midday. Additional 15 minute samples were inserted during acute sampling. These were conducted to detect any immediate changes in drift that may occur during spraying. Pretreatment drift samples were collected from both streams on May 18 and 19, 1984, three days prior to spraying. Acute drift samples were collected on May 22, 23, 24, 31 and June 1, 1984 during spraying of carbaryl. Posttreatment drift samples were collected on July 17, 18, 19 and October 22, 23 and 24, 1984, approximately 44 and 142 days respectively after carbaryl spraying. The drift sampling and data analysis were conducted as modified from Jacobi (1977). Stream velocities were measured and used to calculate stream discharge, which was used in calculating drift rates.

RESULTS

Benthic Samples

Rio Penasco's pretreatment benthic samples, collected in May, contained a total of 14 different taxa while the June, posttreatment samples

contained only 12 taxa. The Sacramento River's May pretreatment benthic samples contained 16 taxa and the June posttreatment samples contained only seven different taxa (Tables 1 and 2). The dominate taxa in the May Rio Penasco samples were Hydropsychidae (Caddisfly), Oligochaeta (Aquatic earthworms), Glossosomatidae (Saddlecase Makers) and Planariidae (Flatworms). They composed 44, 18, 14 and 11 percent respectively of the total (n=1897/SQM). In comparison, Hydropsychidae, and Chironomidae (Midges), and Planariidae were dominate in the June, posttreatment benthic samples at 15, 48 and 23 percent respectively of the total (n=1883/SQM). Ephemeroptera (Mayflies), two types of Plecoptera (Stoneflies), Glossosomatidae and Hirudinea (leeches) were present in the Rio Penasco's May pretreatment samples but were not found in the June posttreatment samples. Moreover, one form of Trichoptera decreased from approximately 104/SQM in the pretreatment samples to 28/SQM in the posttreatment samples, which constitutes an approximate 73 percent decrease. Likewise, Plecoptera, Oligochaeta and Hydropsyche decreased from their May pretreatment densities 84, 77 and 65 percent respectively. Conversely, Chironomidae increased from approximately 21/SQM in the May Rio Penasco's pretreatment sample to 911/SQM in the June posttreatment sample, constituting a 4238 percent increase. Planariidae increased from 337/SQM in May to 433/SQM in June which is a 112 percent increase.

The Rio Penasco's October posttreatment samples contained an approximate total organism density of 465/SQM. When compared with the May pretreatment densities, these data indicate a 75 percent decrease in total densities of organisms contained in the October samples (Figure 2).

Chironomidae, Baetidae (small minnow mayflies) and Heptageniidae (Flatheaded mayflies) at 28, 20 and 14 percent respectively, were dominate in the Sacramento River's May pretreatment samples (n=1018/SQM) (Table 2). Four forms of Ephemeroptera, two forms of Plecoptera, one of three Trichopterans, one of three Dipterans, Gastropoda (snails), Oligochaeta and Arachnida were present in May pretreatment samples but were not found in June posttreatment samples from the Sacramento River. This represents a 56 percent decrease in species composition from May pretreatment to June posttreatment conditions in the Sacramento River samples. Furthermore, a comparison of May pretreatment and June posttreatment sample densities of Tipulidae (crane flies), Hydropsychidae, Limnephilidae and Chironomidae, which were present in both sample sets, showed decreases of 87, 52, 48 and 33 percent respectively. Likewise, the total density of organisms decreased in samples collected from the Sacramento River, from approximately 1018/SQM in May pretreatment samples to 308/SQM in June posttreatment samples, which is a 70 percent decrease.

Drift Samples

Preliminary analysis of drift samples from the Rio Penasco show that total volumes of drifting macroinvertebrates (per 100 cubic meters of

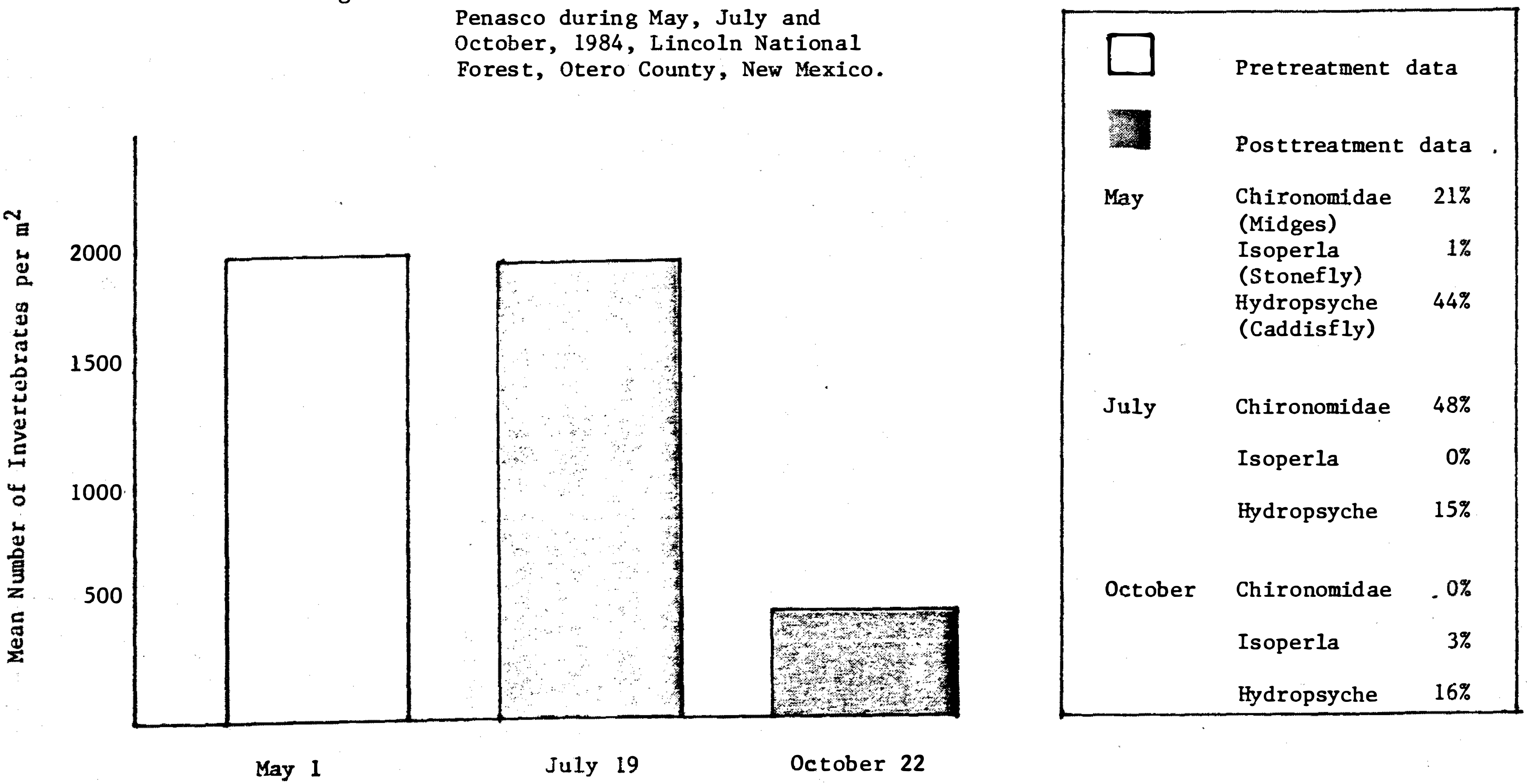
Table 1. Species composition of May pretreatment and June posttreatment benthic samples collected from the Rio Penasco during 1984.

Class	Order	Family	Genus	Pretreatment Density Mean No/SQM	Posttreatment Density Mean No/SQM
Insecta	Ephemeroptera	Baetidae	<u>Baetis</u>	46.63	-
Insecta	Plecoptera			14.35	-
Insecta	Plecoptera	Nemouridae	<u>Zapada</u>	-	7.17
Insecta	Plecoptera	Perlodidae	<u>Isoperla</u>	21.52	-
Insecta	Plecoptera			7.17	-
Insecta	Trichoptera			104.01	28.69
Insecta	Trichoptera	Hydropsychidae	<u>Hydropsyche</u>	824.93	290.52
Insecta	Trichoptera	Glossosomatidae	<u>Glossosoma</u>	258.24	-
Insecta	Trichoptera	Limnephilidae	<u>Psychoronia</u>	-	3.59
Insecta	Coleoptera	Elimidae		28.69	25.11
Insecta	Diptera	Chironomidae		21.52	911.01
Insecta	Diptera	Ceratopogonidae		10.76	28.69
Insecta	Diptera	Empioidae		-	50.21
Hirudinea				7.17	-
Turbellaria	Tricladida	Planariidae	<u>Planaria</u>	204.44	433.99
Oligochaeta				337.15	78.91
Arachnida	Hydracarina			10.76	3.59
Totals				1897.35	1883.00

Table 2. Species composition of May pretreatment and June posttreatment benthic samples collected from the Sacramento River during 1984.

Class	Order	Family	Genus	Pretreatment Density Mean No/SQM	Posttreatment Density Mean No/SQM
Insecta	Ephemeroptera			3.59	-
Insecta	Ephemeroptera	Heptageniidae	Cinygmula	143.47	-
Insecta	Ephemeroptera	Siphlonuridae	Ameletus	86.08	-
Insecta	Ephemeroptera	Baetidae	Baetis	200.85	-
Insecta	Plecoptera			17.93	-
Insecta	Plecoptera	Perlodidae	Isoperla	25.11	-
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	82.49	39.45
Insecta	Trichoptera	Limnephilidae	psychoronia	82.49	43.04
Insecta	Trichoptera	Glossosomatidae	Glossosoma	17.93	-
Insecta	Trichoptera			-	21.52
Insecta	Diptera	Tipulidae	Dicranota	32.28	3.59
Insecta	Diptera	Chironomidae		283.35	190.09
Insecta	Diptera	Empididae		10.76	-
Insecta	Coleoptera	Dytiscidae		-	7.17
Gastropoda		Physidae	Physa	3.59	-
Pelecypoda				3.59	-
Oligochaeta				7.17	3.59
Arachnida	Hydracarina			17.93	
Totals				1018.61	308.45

Figure 2. Benthos Recorded from the Rio Penasco during May, July and October, 1984, Lincoln National Forest, Otero County, New Mexico.



water per 15 minute sample) increased sharply in May 22 and 24 acute samples when compared with May pretreatment, May 31 acute and July-October posttreatment samples. The increase is most notable when comparing the pretreatment May 19 midday sample with the acute May 24 midday sample and the October 23 midday sample (Figure 3). Midday drift volumes increased approximately 99 percent from May 18 to 24 and decreased 98 percent from May 24 to October 23. Differences in drift patterns varied considerably between sampling periods. During the pretreatment May 18 and 19 period the volume of drifting organisms increased from 50/100m^3 water at midday on May 18 to near 300 at midnight and decreased to nearly 100 at midday on May 19. In the May 21, 22 period drift volumes increased from approximately 200/100m^3 water in the pretreatment May 21 evening sample to near 400 at midnight and dropped to 200 in the May 22 morning acute sample and increased sharply to near 1,000/100m^3 water in the evening sample. They declined from evening volumes to near 500 at midnight and declined further to near 300 in the May 22 morning sample. The May 24 acute sample period showed drastic changes in drift patterns. There were approximately 200/100m^3 water in the morning sample and a slight decrease in the midmorning sample. The volume of drift then increased 2,400 percent from midmorning to midday to approximately 5,000/100m^3 water.

The May 24 midday acute period event is what instigated the sampling conducted on Wills Canyon, a tributary to the Rio Penasco. Drift samples were collected from Wills Canyon on May 24 just above its confluence with the Rio Penasco and from the Rio Penasco just above its confluence with Wills Canyon (Figure 4). Both sample sets were compared to each other and to midday sample data from the permanent sample station located on the mainstem Rio Penasco below the confluence of both streams (Figure 5). Drift volumes in the midday sample in the mainstem of the Rio Penasco increased from approximately 200 to 5,000/100m^3 water. A sample collected from Wills Canyon at 15:15 hrs, May 24, contained an approximate total volume of drifting organisms of 12,370/100m^3 water. Conversely, the sample collected from the Rio Penasco, at 15:45 hrs, May 24, above its confluence with Wills Canyon contained a drift volume of only 180/100m^3 water. Posttreatment drift samples were taken from the three locations again on July 19. The posttreatment midday sample from the mainstem Rio Penasco contained a total drift volume of approximately 400/100m^3 while the upper Rio Penasco and Wills Canyon samples, collected at 14:30 hrs, contained approximately 75 and 31/100m^3 water respectively.

Total volumes of drifting organisms contained in all samples collected from the Rio Penasco in October were reduced in comparison to all previous data. Less than 100/100m^3 water were found in any of the four October samples.

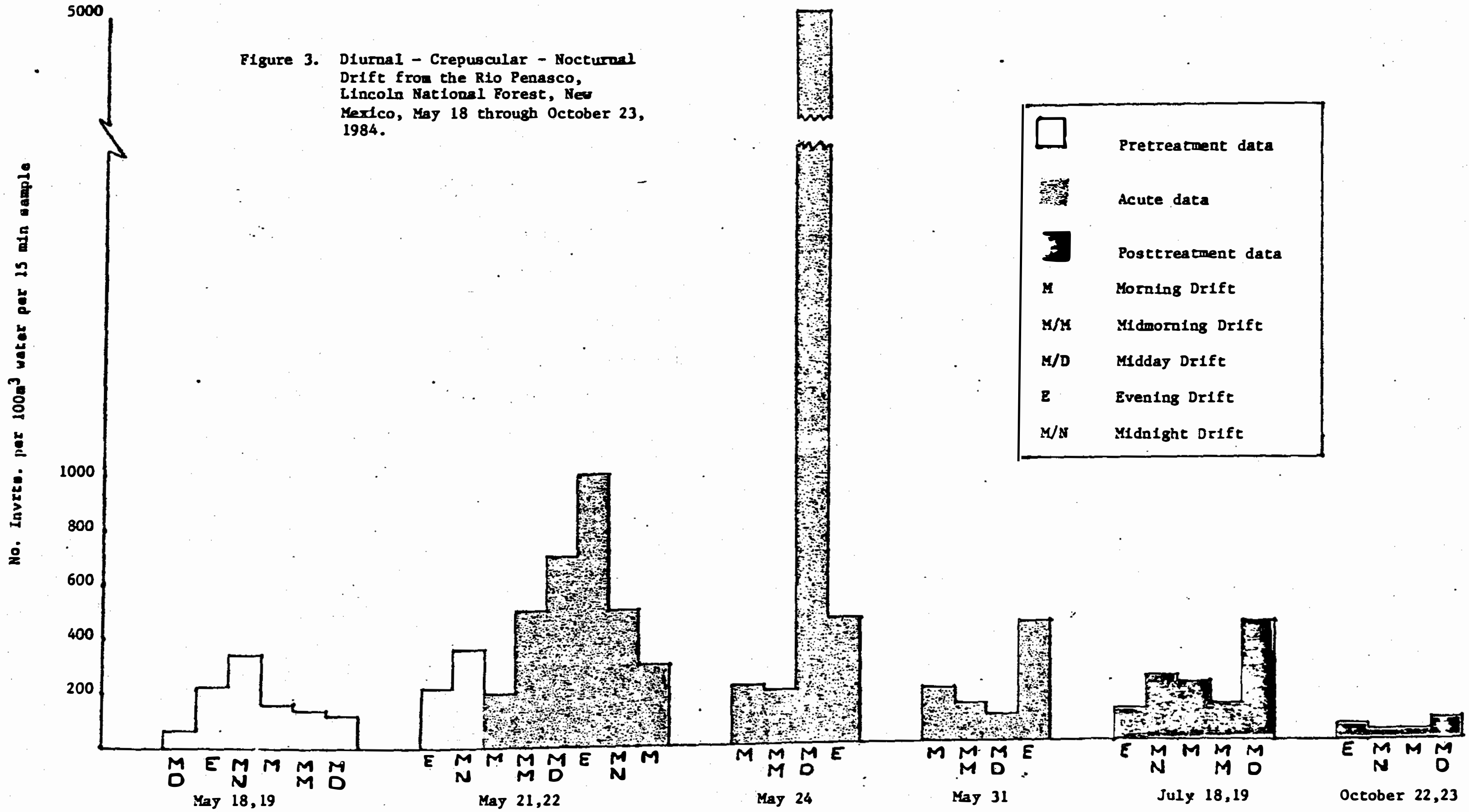


Figure 3. Diurnal - Crepuscular - Nocturnal Drift from the Rio Penasco, Lincoln National Forest, New Mexico, May 18 through October 23, 1984.

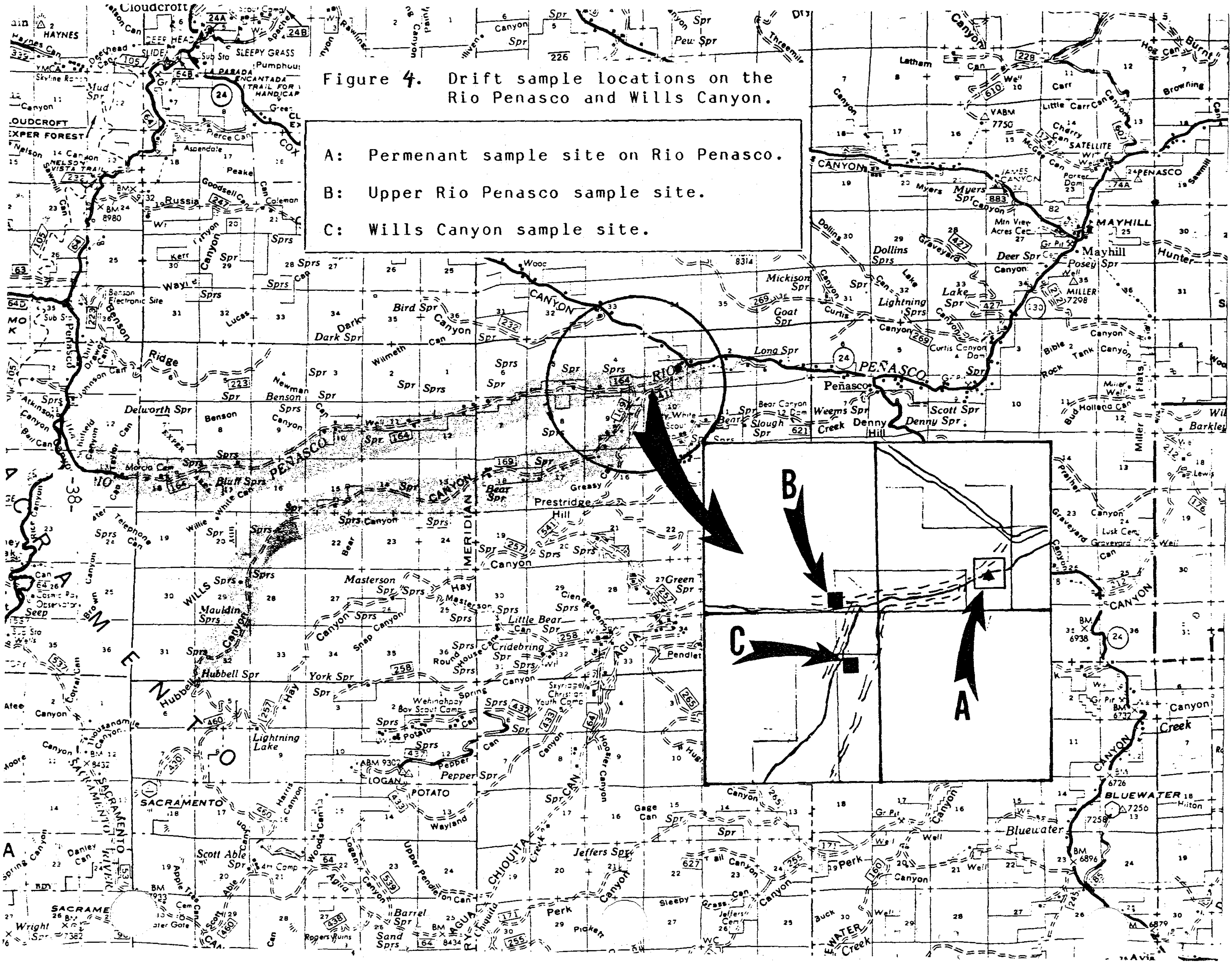
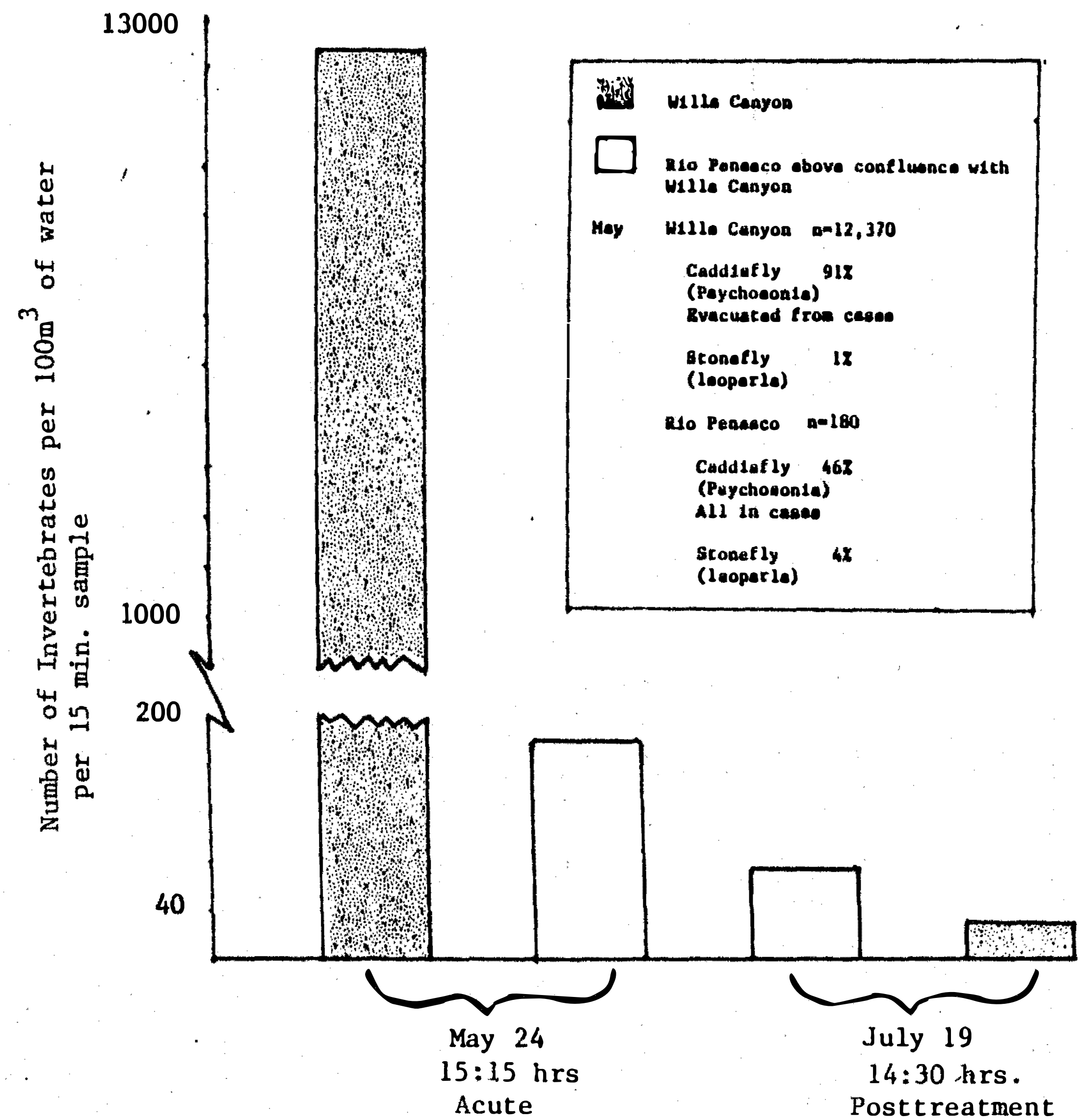


Figure 4. Drift sample locations on the Rio Penasco and Wills Canyon.

Figure 5. Acute and posttreatment drift (15 minute samples) data from the Rio Penasco and Wills Canyon tributary above sample station during May and July, 1984, Lincoln National Forest, Otero County, New Mexico.



DISCUSSION

The results of the sampling and analysis presented here indicate that carbaryl contamination of the Rio Penasco and Sacramento River occurred and resulted in the mortality of some aquatic macroinvertebrates. Comparison of pretreatment and posttreatment benthic data from the Rio Penasco showed the disappearance of five out of 14 species of invertebrates in posttreatment samples that were present in pretreatment samples. Moreover, sample densities of four other species decreased significantly in Rio Penasco posttreatment samples when compared to their pretreatment sample densities. Likewise these data indicate a 75 percent decrease in total densities of organisms in posttreatment samples when compared to pretreatment densities.

Sacramento River benthic data showed that 11 of 16 species found in May pretreatment samples were not found in June posttreatment samples. Furthermore, four others, present in posttreatment samples, showed significant reductions in sample densities. And the total density of organisms in the Sacramento River samples decrease 70 percent from pretreatment to posttreatment conditions.

Drift samples from the Rio Penasco show drastic fluctuations in volumes of drifting organisms. Data collected during spraying on May 24 shows a 2,400 percent increase in drift volume from midmorning to midday and a 91 percent decrease from midday to evening. Conversely, May 19 pretreatment data shows a 20 percent decrease in drift volumes from midmorining to midday and on May 22 a 40 percent increase was shown.

Observations made of the May 24 midday sample showed that most all organisms in the sample were dead. Further examination revealed that 53 percent of the sample were Caddisfly larvae (Psychoronia) of which 99 percent had evacuated their cases.

Later discussions with participants of the spray program revealed that an overspray of Wills Canyon with carbaryl did occur on the morning of May 24, 1984.

Discussions of the recovery of affected macroinvertebrate populations in these streams is limited due to the lack of control data. No control stream was available in or near the study area for sampling. Therefore, in order to better address the question of recovery, we recommend that the May pretreatment and July and October posttreatment data sets be replicated on both streams.

RECOMMENDATION

In order to better determine the recovery of affected aquatic macroinvertebrates by carbaryl spraying in the Rio Penasco and Sacramento River we recommend that the replication of May pretreatment and July and October posttreatment sampling efforts be accomplished and included in a comprehensive analysis of all data and the preparation of a report of its findings in FY 86. We have prepared a recommended scope of work to accomplish this task for your convenience (enclosed).

Sincerely yours,

Thomas F. O'Brien

Tom O'Brien
Acting Field Supervisor

Enclosure

cc:
Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico
Regional Director, FWS, Habitat Resources, Albuquerque, New Mexico

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